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A LATE TERTIARY DIATOM FLORA FROM OREGON

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Abstract: Siliceous microfossils including diatoms, radiolaria and silicoflagellates were extracted from an exposure of diatomite in southwest Oregon. The diatom flora here is indicative of a Late Miocene (Delmontian) age and represents a coastal temperate environment.

Introduction

A small exposure of marine diatomite in the vicinity of Bandon, Oregon, was sampled and processed for microfossils. In addition to a diverse radiolarian fauna and a few silicoflagellates, some 15 species of diatoms were successfully extracted. Although a number of diatom floras have been described from nonmarine sediments in Oregon, marine diatomites are rare in this state and elsewhere in the Pacific Northwest, and little has been published on siliceous marine microfossils from this area. By comparison, exposures of marine diatomites in California are well known, and much has been published with regard to siliceous plant and animal microfossils in that state. Recent papers by Wornardt (1967a, b) are a particularly useful review of the biostratigraphy, taxonomy, and distribution of late Tertiary diatoms in California.

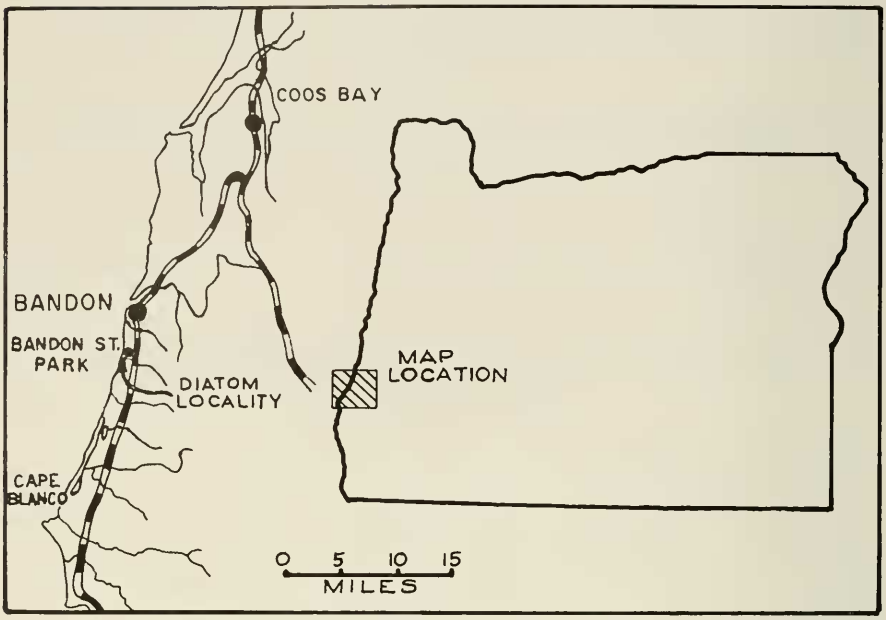

FIGURE 1. Locality map in southeast Oregon.

LOCALITY AND LITHOLOGY

Approximately 30 stratigraphic feet of diatomite is exposed just above the high-tide mark on the beach adjacent to Bandon State Park on Beach Loop Road three miles south of Bandon, Oregon (fig. 1). Steps down to the beach have been carved in the soft diatomite at the locality. The base of the unit which dips gently to the north is not exposed, and the top is unconformably overlain by sand dunes. The rock is cream colored on weathered exposures and buff where it is fresh. Considerable limonite staining occurs along fractures running through

TABLE 1. *Percentage occurrence of genera from three localities: University of Oregon Museum of Natural History, Localities 2569, 2570, 2571.*

Genera	*Percent*
Coscinodiscus spp.	~ 97
Stephanopyxis sp.	~ 1
Lithodesmium sp.	< 1
Arachnoidiscus sp.	< 1
Stictodiscus sp.	< 1
Actinocyclus spp.	< 1
Actinoptychus spp.	< 1

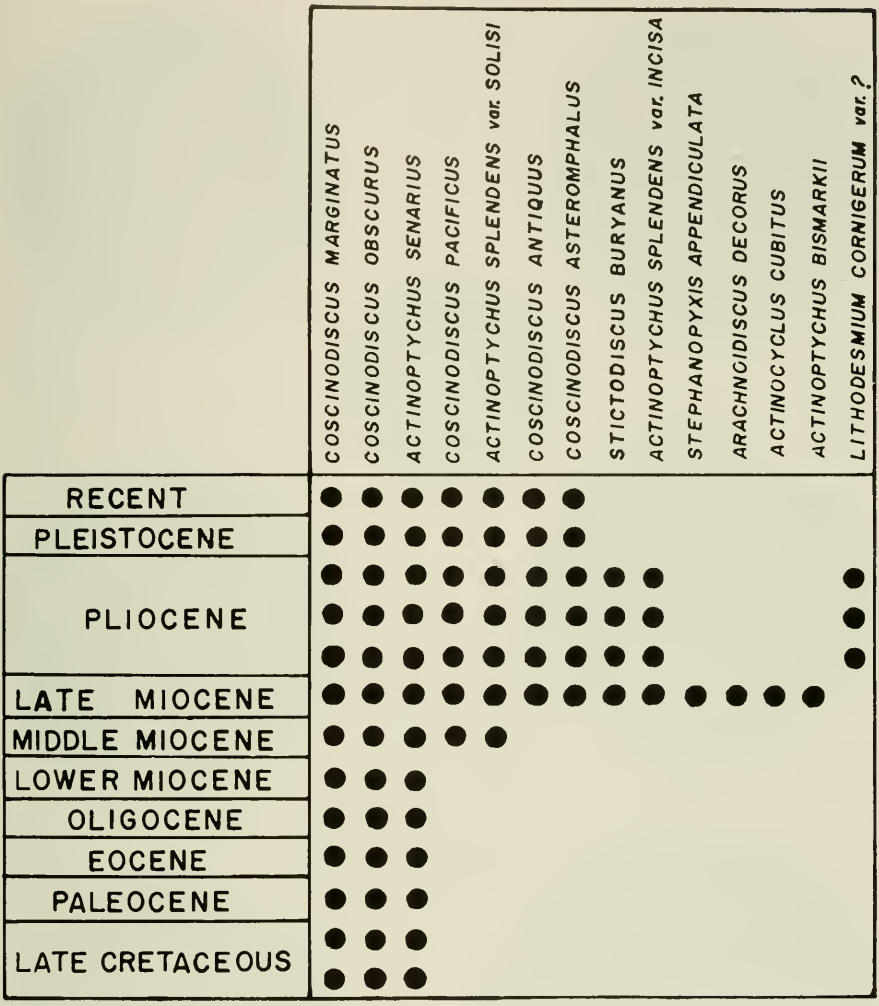

FIGURE 2. Published age distribution of diatom species from Bandon.

the fine-grained massive diatomite. Using estimates of acid-treated residues and thin sections, the rock was found to exceed 75 percent organically precipitated silica. Of this siliceous fraction, more than 95 percent is in the form of diatom frustules and the remaining five percent is skeletal material from radiolaria and silicoflagellates. The remaining 25 percent nonsiliceous portion of the rock is very fine terriginous material which occurs in thin layers and imparts the only visible stratification to the rock. Three samples were collected from evenly spaced stratigraphic intervals and processed separately. These samples were later found to be very homogeneous with regard to the diatom flora.

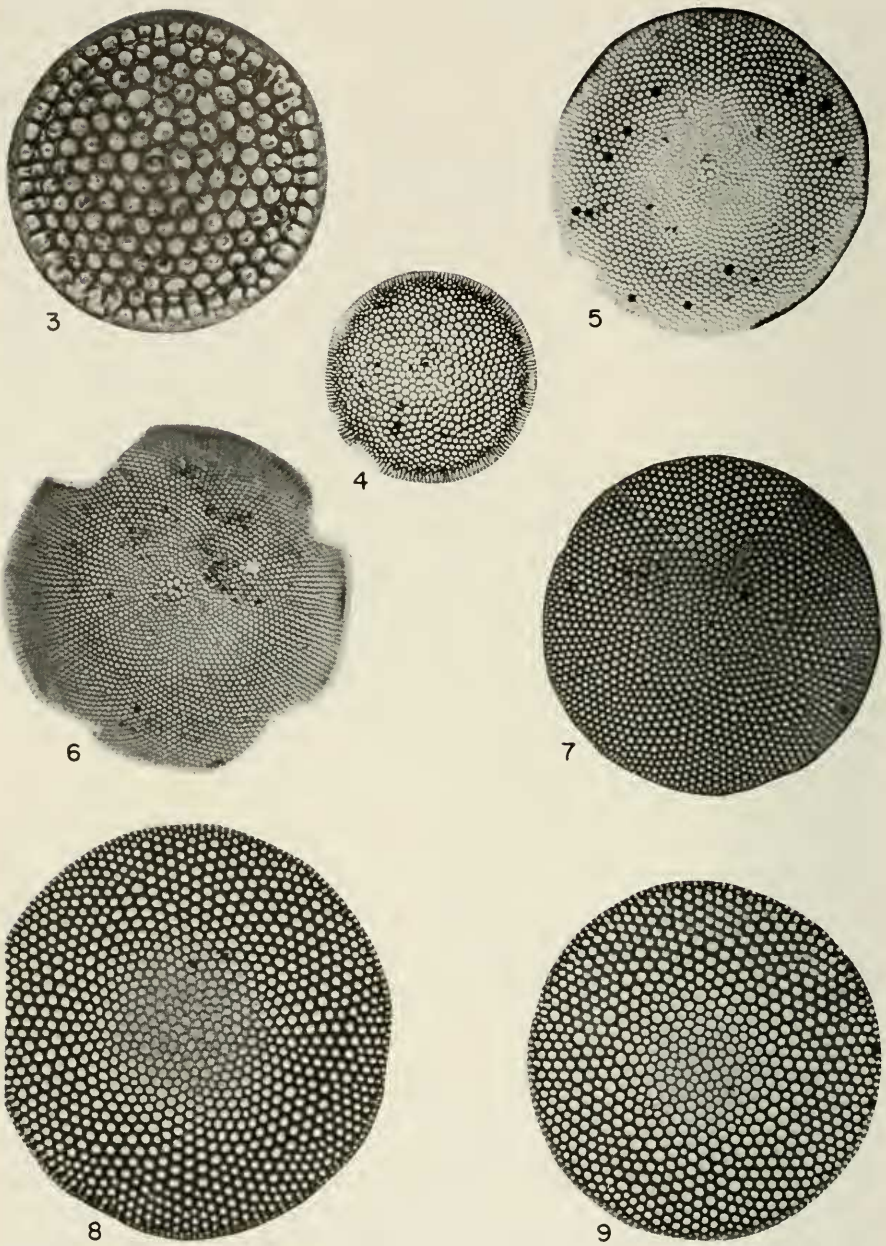

FIGURE 3. *Coscinodiscus marginatus* Ehrenberg. University of Oregon Museum of Natural History. Hypotype number 27466. Diameter 0.115 mm. Univ. of Oregon Mus. Loc. 2569.

FIGURE 4. *Coscinodiscus marginatus* Ehrenberg. University of Oregon Museum of Natural

Floral Composition and Environment

Species of *Coscinodiscus* (table 1) clearly dominate the Bandon flora which is characterized by the abundance of *C. marginatus*, *C. asteromphalus*, and *C. pacificus*. Of the seven species in this flora that range into the Recent, *C. marginatus* Ehrenberg and *C. asteromphalus* Ehrenberg are ubiquitous in modern oceanic plankton at various latitudes (Hendey 1937, 1964; Lohman 1941). Two other species, *C. obscurus* Schmidt and *Actinoptychus senarius* Ehrenberg, are most common in temperate seas, but are also widely distributed (Hendey, 1957; Cupp, 1943). Almost all of the modern species in the present flora are either neritic pelagics or benthonics. The excellent preservation of the specimens at Bandon and the lack of evidence of diagenetic alteration indicate that the fossil assemblage fairly represents the original flora. Because many of the forms are geographically wide ranging, precision is difficult, but the abundance of benthonics and temperate species and the absence of dominantly tropical or polar species imply a shallow coastal environment not markedly different from the adjacent ocean.

Geologic Age

Seven of the species in this flora are stratigraphically long-ranging forms which appear in sediments from the Cretaceous or Tertiary to the Recent and are thus of limited biostratigraphic use (fig. 2). The remaining species of diatoms in the Bandon flora are unreported from rocks older or younger than the late Tertiary. Four of the Bandon species, *Stephanopyxis appendiculata* Ehrenberg, *Arachnoidiscus decorus* Brown, *Actinocyclus cubitus* Hanna and Grant, and *Actinoptychus bismarkii* Schmidt, are reported by Wornardt (1967) as stratigraphically restricted to the late Miocene in California. The presence of these four species in the flora by themselves would clearly imply a late Miocene age. However, also present in the flora are fragments and small valves of a diatom resem-

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History. Hypotype number 27467. Diameter 0.135 mm. Univ. of Oregon Mus. Loc. 2571.

Figure 5. *Coscinodiscus asteromphalus* Ehrenberg. University of Oregon Museum of Natural History. Hypotype number 27468. Diameter 0.184 mm. Univ. of Oregon Mus. Loc. 2569.

Figure 6. *Coscinodiscus asteromphalus* Ehrenberg. University of Oregon Museum of Natural History. Hypotype number 27469. Diameter 0.205 mm. Univ. of Oregon Mus. Loc. 2569.

Figure 7. *Coscinodiscus obscurus* Schmidt. University of Oregon Museum of Natural History. Hypotype number 27470. Diameter 0.112 mm. Univ. of Oregon Mus. Loc. 2570.

Figure 8. *Coscinodiscus pacificus* Rattray. University of Oregon Museum of Natural History. Hypotype number 27471. Diameter 0.145 mm. Univ. of Oregon Mus. Loc. 2569.

Figure 9. *Coscinodiscus pacificus* Rattray. University of Oregon Museum of Natural History. Hypotype number 27472. Diameter 0.128 mm. Univ. of Oregon Mus. Loc. 2571.

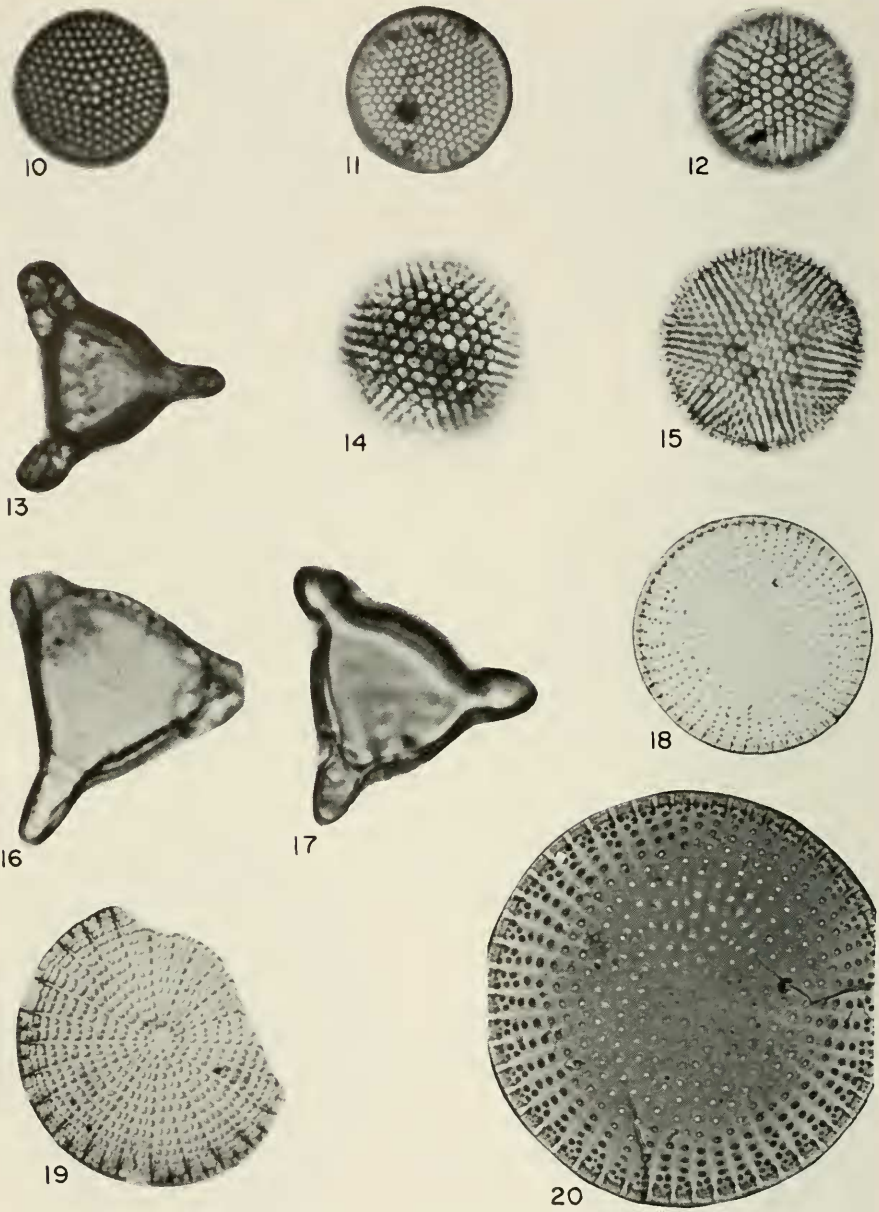

FIGURE 10. *Coscinodiscus antiquus* Grunow. University of Oregon Museum of Natural History. Hypotype number 27473. Univ. of Oregon Mus. Loc. 2569. Diameter 0.052 mm.

FIGURE 11. *Coscinodiscus antiquus* Grunow. University of Oregon Museum of Natural History. Hypotype number 27474. Univ. of Oregon Mus. Loc. 2571. Diameter 0.065 mm.

FIGURE 12. *Stephanopyxis appendiculata* Ehrenberg. University of Oregon Museum of

bling *Lithodesmium cornigerum* Brun. This latter species is regarded by authors (Wornardt, 1967; Hanna, 1930; Lohman, 1938) as a guide fossil to the Pliocene. Contamination of the Bandon flora by the four late Miocene species seems unlikely and the identification of *L. cornigerium* Brun is discussed under systematics. Because all of the species are regarded as representative of the original flora and not contaminants, the evidence suggests a late Miocene (Delmontian) age for the Bandon flora. The co-occurence of the four late Miocene species and the Pliocene *L. cornigerium* Brun in the Bandon flora may extend the range of this latter species into the upper Miocene.

The silicoflagellate flora extracted from these sediments (Orr and Zaitzeff, 1970) corroborates this diatom correlation.

Systematics

Because of the limited number of most species in the Bandon flora, this section on systematics is not intended to be a detailed examination of the species. The reader is directed to Wornardt (1967) for a more comprehensive taxonomic treatment of the species identified here.

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Natural History. Hypotype number 27475. Univ. of Oregon Mus. Loc. 2569. Diameter 0.105 mm.

Figure 13. *Lithodesmium cornigerum* Brun. var.? University of Oregon Museum of Natural History. Hypotype number 27478. Univ. of Oregon Mus. Loc. 2570. Diameter 0.079 mm.

Figure 14. *Stephanopyxis appendiculata* Ehrenberg. University of Oregon Museum of Natural History. Hypotype number 27476. Univ. of Oregon Mus. Loc. 2569. Diameter 0.112 mm.

Figure 15. *Stephanopyxis appendiculata* Ehrenberg. University of Oregon Museum of Natural History. Hypotype number 27477. Univ. of Oregon Mus. Loc. 2570. Diameter 0.135 mm.

Figure 16. *Lithodesmium cornigerum* Brun. var.? University of Oregon Museum of Natural History. Hypotype number 27479. Univ. of Oregon Mus. Loc. 2571. Diameter 0.111 mm.

Figure 17. *Lithodesmium cornigerum* Brun. var.? University of Oregon Museum of Natural History. Hypotype number 27480. Univ. of Oregon Mus. Loc. 2569. Diameter 0.085 mm.

Figure 18. *Stictodiscus buryanus* Grunow. University of Oregon Museum of Natural History. Hypotype number 27482. Univ. of Oregon Mus. Loc. 2569. Diameter 0.144 mm.

Figure 19. *Arachnoidiscus decorus* Brown. University of Oregon Museum of Natural History. Hypotype number 27481. Univ. of Oregon Mus. Loc. 2569. Diameter 0.165 mm.

Figure 20. *Stictodiscus buryanus* Grunow. University of Oregon Museum of Natural History. Hypotype number 27482. Univ. of Oregon Mus. Loc. 2569. (Same specimen as fig. 18 at higher magnification.)

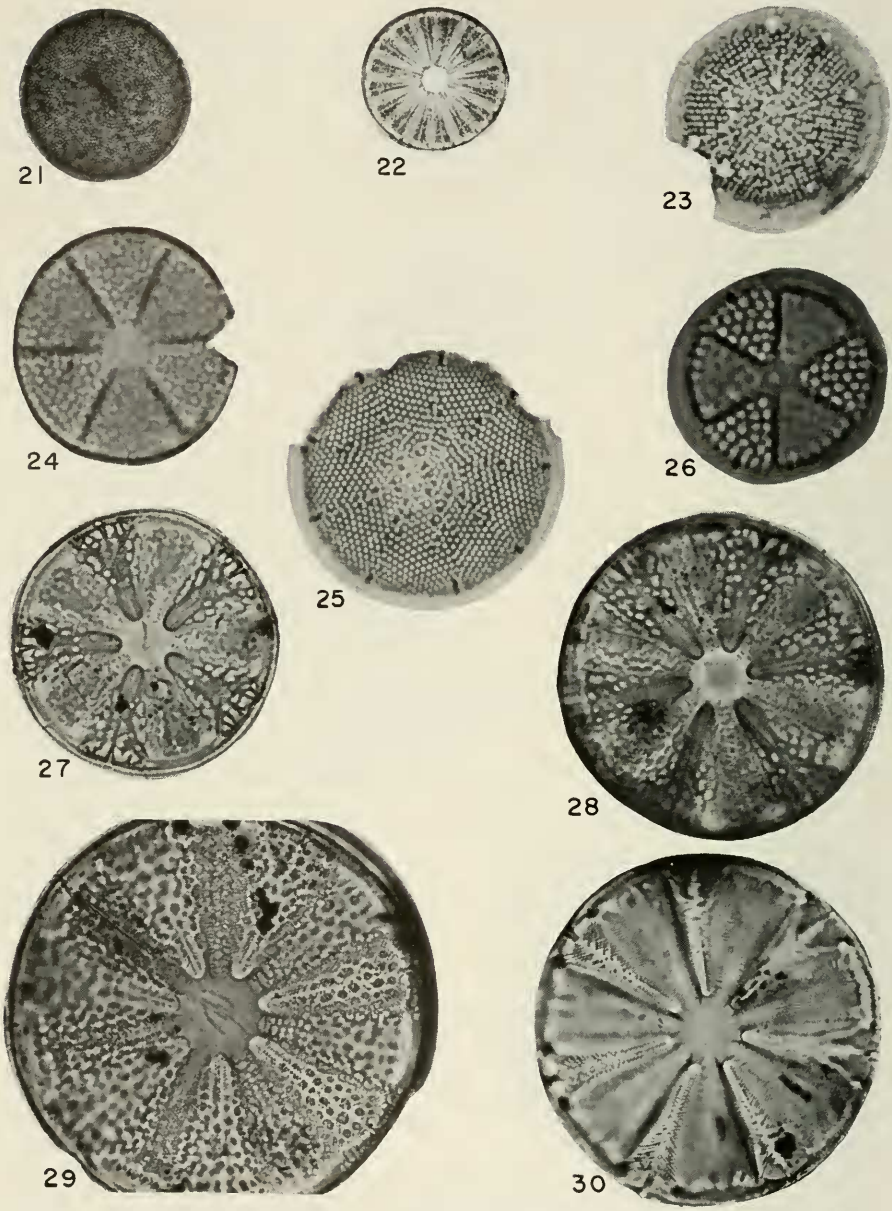

FIGURE 21. *Actinocyclus* species. University of Oregon Museum of Natural History. Hypotype number 27483. Univ. of Oregon Mus. Loc. 2569. Diameter 0.085 mm.

FIGURE 22. *Actinoptychus splendens* var. *incisa* (Grunow). University of Oregon Museum of Natural History. Hypotype number 27485. Univ. of Oregon Mus. Loc. 2570. Diameter 0.095 mm.

PLANT KINGDOM

Division CHRYSOPHYCOPHYTA

Class BACILLARIOPHYCEAE Fritsch, 1935

Order Bacillariales Schütt, 1896

Family Coscinodiscaceae Kützing, 1844

Genus **Stephanopyxis** Ehrenberg, 1845

Stephanopyxis appendiculata Ehrenberg.
(Figures 12, 14, 15.)
Stephanopyxis appendiculata Ehrenberg, 1854, pl. 18, fig. 4; Wornardt, 1967, p. 17, figs. 12, 13.

Genus **Coscinodiscus** Ehrenberg, 1838

Coscinodiscus antiquus (Grunow) Rattray.
(Figures 10, 11.)
Coscinodiscus antiquus (Grunow) Rattray, 1889, p. 461; Wornardt, 1967, p. 20, fig. 23.

Coscinodiscus asteromphalus Ehrenberg.
(Figures 5, 6.)
Coscinodiscus asteromphalus Ehrenberg, 1854, pl. 18, fig. 45; Wornardt, 1967, p. 20, figs. 14–18.

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Figure 23. *Actinocyclus cubitus* Hanna and Grant. University of Oregon Museum of Natural History. Hypotype number 27486. Univ. of Oregon Mus. Loc. 2569. Diameter 0.075 mm.

Figure 24. *Actinoptychus senarius* Ehrenberg. University of Oregon Museum of Natural History. Hypotype number 27487. Univ. of Oregon Mus. Loc. 2569. Diameter 0.075 mm.

Figure 25. *Actinocyclus* species. University of Oregon Museum of Natural History. Hypotype number 27484. Univ. of Oregon Mus. Loc. 2570. Diameter 0.065 mm.

Figure 26. *Actinoptychus bismarkii* Schmidt. University of Oregon Museum of Natural History. Hypotype number 27488. Univ. of Oregon Mus. Loc. 2571. Diameter 0.075 mm.

Figure 27. *Actinoptychus splendens* var. *solisi* Hanna and Grant. University of Oregon Museum of Natural History. Hypotype number 27489. Univ. of Oregon Mus. Loc. 2569. Diameter 0.090 mm.

Figure 28. *Actinoptychus splendens* var. *solisi* Hanna and Grant. University of Oregon Museum of Natural History. Hypotype number 27490. Univ. of Oregon Mus. Loc. 2569. Diameter 0.115 mm.

Figure 29. *Actinoptychus splendens* var. *solisi* Hanna and Grant. University of Oregon Museum of Natural History. Hypotype number 27491. Univ. of Oregon Mus. Loc. 2570. Diameter 0.155 mm.

Figure 30. *Actinoptychus splendens* var. *solisi* Hanna and Grant. University of Oregon Museum of Natural History. Hypotype number 27492. Univ. of Oregon Mus. Loc. 2570. Diameter 0.125 mm.

Coscinodiscus marginatus Ehrenberg.
(Figures 3, 4.)
Coscinodiscus marginatus Ehrenberg, 1854, pl. 18, fig. 44; Wornardt, 1967, p. 26, figs. 27, 28.

Coscinodiscus obscurus Schmidt.
(Figure 7.)
Coscinodiscus obscurus Schmidt, 1878, pl. 61, fig. 16; Wornardt, 1967, p. 27, fig. 32.

Coscinodiscus pacificus Rattray.
(Figures 8, 9.)
Coscinodiscus pacificus Rattray, 1890, p. 563; Wornardt, 1967, p. 30, figs. 36, 37.

Genus **Actinocyclus** Ehrenberg, 1838

Actinocyclus cubitus Hanna and Grant.
(Figure 23.)
Actinocyclus cubitus Hanna and Grant, 1926, p. 118, pl. 11, fig. 3. Wornardt, 1967, p. 33, figs. 47, 48.

Actinocyclus species.
(Figures 21, 25.)

Specimens of this species of *Actinocyclus* in the Bandon flora closely resemble a diatom figured and identified as *A. ehrenbergii* Ralfs by Lohman (1938) plate 22, figure 1. Lohman (1941) places this same reference in synonymy with *A. octonarius* Ehrenberg as does Wornardt (1967). Specimens figured and identified as *A. octonarius* in these latter two references do not, however, resemble the Bandon specimens.

Family Actinodiscaceae Schütt, 1896

Genus **Stictodiscus** Greville, 1861

Stictodiscus buryanus Grunow.
(Figures 18, 20.)
Stictodiscus buryanus Grunow, Hustedt, *in* Schmidt, 1940, pl. 441, fig. 9, pl. 442, fig. 1; Wornardt, 1967, p. 38, fig. 52.

Genus **Arachnoidiscus** Bailey, from Ehrenberg, 1849

Arachnoidiscus decorus Brown.
(Figure 19.)
Arachnoidiscus decorus Brown, Wornardt, 1967, p. 40, fig. 53.

Genus **Actinoptychus** Ehrenberg, 1943

Actinoptychus bismarkii Schmidt.
(Figure 26.)
Actinoptychus bismarkii Schmidt, 1886, pl. 91, fig. 4; Wornardt, 1967, p. 42, fig. 65.

Actinoptychus senarius Ehrenberg.
(Figure 24.)
Actinoptychus senarius Ehrenberg, 1838, p. 172, pl. 21, fig. 6; Wornardt, 1967, p. 44, fig. 67.

Actinoptychus splendens var. **incisa** (Grunow).
(Figure 22.)
Actinoptychus incisa GRUNOW, *in* Schmidt, 1890, pl. 154, figs. 2, 3.
Actinoptychus splendens var. *incisa* (GRUNOW); WORNARDT, 1967, p. 48, figs. 68–71, 73.

Actinoptychus splendens var. **solisi** (Hanna and Grant).
(Figures 27, 28, 29, 30.)
Actinoptychus solisi HANNA AND GRANT, 1926, p. 123, pl. 12, figs. 1–3.
Actinoptychus splendens var. *solisi* (Hanna and Grant), WORNARDT; WORNARDT, 1967, p. 48, figs. 74–77.

Family BIDDULPHIACEAE Kützing, 1844

Genus **Lithodesmium** Ehrenberg, 1840

Lithodesmium cornigerum Brun var.?
(Figures 13, 16, 17.)
Lithodesmium cornigerum Brun, HANNA, 1930, p. 189, pl. 14, figs. 9, 10; WORNARDT, 1967, p. 67, fig. 131.

Specimens identified as *L. cornigerum* var.? from the Bandon flora differ from Pliocene forms reported from California (Hanna, 1930; Wornardt, 1967) in that the valves of most of those in the present flora frequently have more club-shaped processes (figs. 13, 17). Typical "propeller" shaped forms mentioned by Wornardt (1967) are nonetheless present (fig. 16). The transition between club and propeller shape appears to be complete within the Bandon flora and the smaller specimens tend to be club shaped. The processes of typical "propeller" shaped forms in the present flora (fig. 16) are shorter than those on Pliocene specimens illustrated by Wornardt (1967) and Hanna (1930).

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